Coastal Engineering Technical Note

SEDIMENT SIZE AND FALL VELOCITY EFFECTS ON LONGSHORE SEDIMENT TRANSPORT

PURPOSE: To present a method for estimating the dimensionless proportionality factor K used in the relationship for predicting cohensionless longshore sediment transport as given in the Shore Protection Manual (SPM) (1984) and presented as follows (Equation 4-48):

$$I_{\ell} = K\ P_{\ell s}$$

The suggested relationship for K will allow SPM equation (4-48) to be extended to sand beaches with varying sediment size and to non-sand beaches (i.e. shell, cobble) where sediment fall velocity is known.

BACKGROUND: Presently the factor K , as given in SPM equation (4-48), is treated as a constant equal to 0.39. The effects of the sediment hydraulic properties and the fluid transporting medium are not included in a constant value of K . A number of studies (Thornton 1972, Dean 1973, Walton and Chiu 1979, Bailard 1981, Dean et al 1982, and Dean 1983) have developed analytic models which suggest that K is not constant but rather a variable dependent on sediment size and density, which may be represented by fall velocity. As an example, Dean et al. (1982) have shown a relationship between K and grain size which suggests that the immersed weight sediment transport rate I_{ℓ} is inversely proportional to the size of the material being transported. A more appealing relationship is one between K and fall velocity of sediment since fall velocity is a hydraulic property of the sediment and accounts for density and viscosity changes in the fluid transporting medium as well as sediment density and size. The viscosity changes with water temperature have been shown to be important to sediment transport in rivers (Vanoni 1975) and a similar effect of temperature (or viscosity) would be expected to occur in longshore sediment transport.

The relationship for K presented here incorporates fall velocity in the form of a dimensionless parameter, gH_b/w^2 . The equation was developed from

field data of sand transport in a manner similar to that done by Dean (1983). The data are plotted and the equation given in Figure 1. The vertical bars on the data points refer to the standard deviation of the data group that make up the point. The number of tests that are averaged to give the data point is in parentheses beside the data point. This relationship is intended to give a conservative estimate for sediment transport as a function of sediment fall velocity and is applicable to field data only

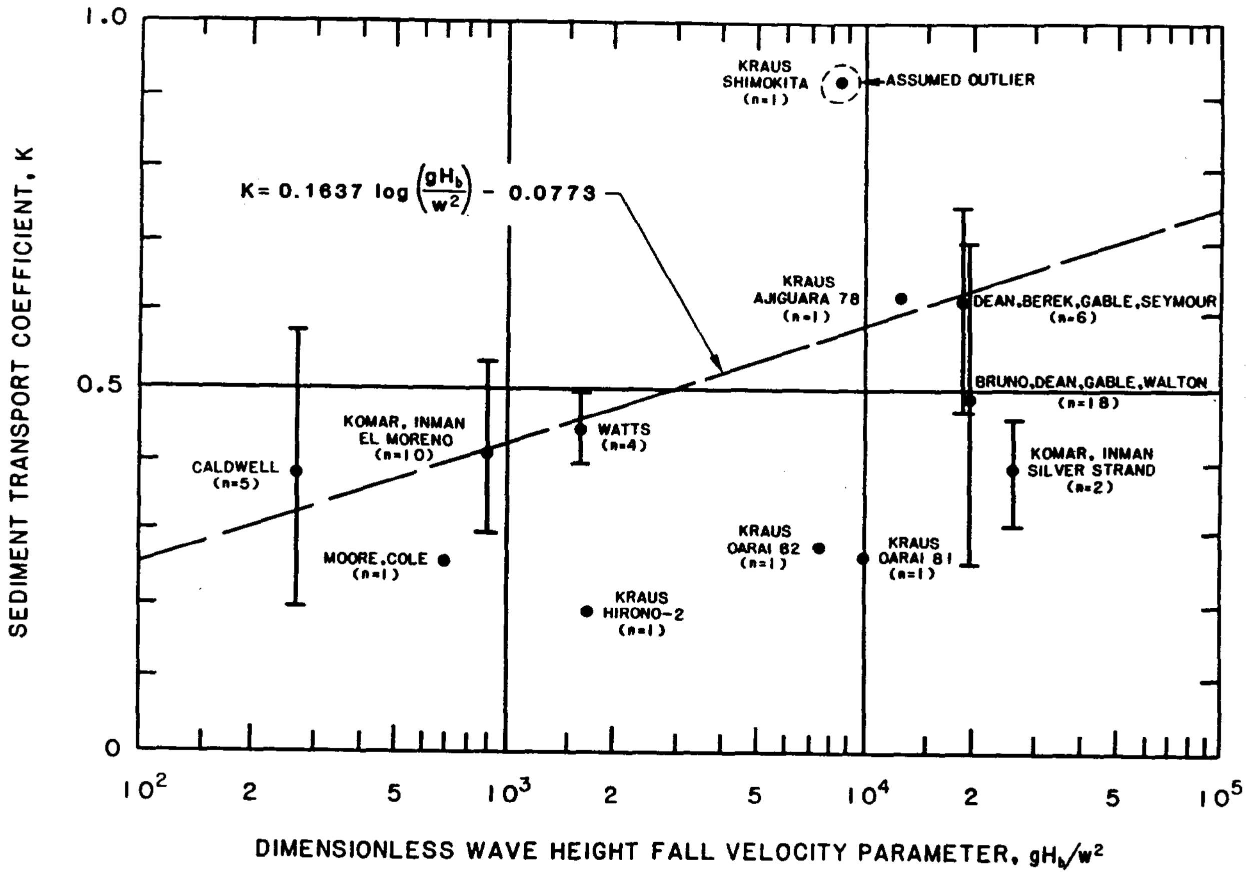

Figure 1. Dimensionless wave height - fall velocity parameter, gH_b/w^2

<u>*METHOD:*</u> The suggested relationship for K (where K is dimensionless and consistent with SPM methods for calculating $P_{\ell s}$) using the dimensionless parameter gH_b/w^2 is

$$K = 0.1637 \log (gH_b/w^2) - 0.0773$$

where

K = dimensionless constant of SPM equation (4-48)

log = logarithmic function to the base 10

g = gravitational constant

H_b = breaking wave height

w = fall velocity of sediment

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GIVEN: $P_{\ell s}$ = 90.2 N/sec = 20.3 lb/sec (calculated from wave data using significant wave height)

H_b = 77.2 cm = 2.53 ft

g = 981 cm/sec^2 = 32.2 ft/sec^2

w = 3.45 cm/sec = 0.113 ft/sec

where w is to be determined experimentally if the spherical grain assumption cannot be applied to the material. This value of fall velocity was obtained for 5 mm shell fragments obtained from a beach consisting of shell tested in 20 C (68 F) seawater.

FIND: The immersed weight transport rate I_ℓ for a beach consisting of shell fragments (calcium carbonate having the above characteristics).

SOLUTION:

$$K = 0.1637 \log [981 (77.2)/(3.45)^2] - 0.0773$$

$$K = 0.55$$

$$I_\ell = K\, P_{\ell s} = (0.55)\ (90.2) = 49.6 \text{ N/sec} = 11.1 \text{ lb/sec}$$

SUMMARY: A method has been presented for estimating K in SPM (1984) equation (4-48) for prototype data. This K is presented as a variable dependent on the dimensionless parameter gH_b/w^2 which takes into account the breaker height and fall velocity of the sediment. The fall velocity accounts for effects of water viscosity and density as well as sediment density, size, and shape characteristics.

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